

Analysis of Science Trade Books Based on Terminology, Illustrations, and Demographics

Aviva Sussman, Amanda Rogers, Julie Libarkin
Los Alamos National Laboratory/Perkiomen School/Ohio University

Abstract

In today's science and technology driven world, it is essential for children to develop the ability to reason, raise and solve pertinent questions, think critically about data, and communicate findings. In 1996, the National Science Education Standards (NSES, National Research Council) outlined basic science standards for kindergarten through twelfth grade. While it is expected that all school curricula will follow these standards, independently written children's trade books, often used in place of science texts and as supplementary material, may not necessarily meet the NSES guidelines. This paper assesses the quality of currently available children's science trade books. To this end, we have compiled data and analyzed the terminology, illustration, and demographics of thirty randomly selected earth science books published between 1979 and 2003. While our case study is geared towards the earth sciences, this content analysis can readily be applied to other fields such as engineering. The data and results compiled in this study are designed to facilitate efforts by teachers, parents, and guardians to determine which books best fit their teaching needs. This work is an important first step in analyzing the quality of currently available supplementary science education materials and in determining a course of action to improve that quality. Results of the content analysis suggest that recently published books may transmit more information, as the number of scientific terms, and the number of those terms which are defined have increased. On the other hand, there does not appear to be any increase in demographic diversity of characters represented in the books. Thus, while the intellectual quality of children's trade books with respect to earth science content has generally increased through time, the children who relate to such books may reflect the narrow range of characters depicted in the books' illustrations.

Introduction

The use of science trade books as instructional tools has a long history, particularly in primary education. Teachers routinely incorporate trade books with scientific themes into their instruction, often using such books as a springboard for discussion with students and further exploration of natural phenomena (e.g., Wenzel, 2003). The use of formal science textbooks has been diminishing in recent years (Tolman et al., 1998), perhaps as a result of studies that call for the replacement of formal texts with science trade books (e.g., Butzow and Butzow, 1988; Mayer, 1995). Indeed, many school systems now require the use of trade books in science instruction. The National Science Teacher's Association (NSTA) advocates the use of trade books in elementary science instruction and publishes an annual list of the "best" new science trade books (<http://www.nsta.org/ostbc>). Although many teachers use trade books in science instruction, the choice of books and the curriculum used along with chosen texts can vary dramatically between teachers (Donovan and Smolkin, 2001). Science trade books can take several forms. These books can be strictly story-oriented (such as *The Pebble in My Pocket*,

Hooper and Coady, 1996), primarily fact-focused (*Our World: Rocks and Soil*, Morris, 2002), or combined-text, wherein stories and informational text exist within a single book (*The Magic School Bus* Series; Chapman and Sopko, 2003).

How and why teachers choose particular trade books for science instruction is poorly understood, although recent studies shed some light on teacher's choices. According to Donovan and Smolkin (2001), teachers focus on four characteristics when choosing trade books: content, visual features, readability, and perception that books are "fun" or "enjoyable". Multicultural or gender issues seem to play a limited role in both research related to science trade books and selection of books by teachers, although children may have difficulty relating to monocultural books (Matthews et al., 1995). Finally, the NSTA's list of best books likely influences text selection, as do published reviews of science trade books (e.g., Wenzel, 2003). While the criteria used by NSTA in generating the best books list are clearly delineated on the NSTA website (<http://www.nsta.org/ostbcprocess>), determining a book's value is highly susceptible to subjective preferences, such as a inclination towards computer generated images rather than hand drawn pictures. An objective quantitative method which can accurately assess, without bias, the quality of science trade books is needed as a first-step towards determining which books would be most beneficial for instruction.

Alternative Conceptions and Trade Books

Trade books used in elementary science instruction are typically not written by scientists, and communication of scientific concepts are not necessarily an author's intention. For example, the Moon is a common theme in many children's books (e.g., *Stellaluna*, Cannon, 1993). Generally, illustrations of the Moon sacrifice accuracy for artistry, presenting the Moon with an unrealistic shape, size, or distance from the Earth (Rice et al., 2001, etc.). In addition, the mixing of fantasy and fact in combined-text books (Chapman and Sopko, 2003) can lead children to create unrealistic ideas about natural phenomena. For instance, Owens (2003) reports an anecdotal exchange with a teacher who discovered that third grade students believed chameleons could adapt to any background by changing skin patterns, including adoption of polka dots and stripes. These ideas were directly related to several trade books about chameleons available in the school library.

An "alternative conception" is a non-scientific idea about natural phenomena such as the chameleon example described above. In light of the apparent prevalence of alternative conceptions contained within trade books, we must consider both the prevalence of these conceptions in choosing books and the possibility that trade books may be a source of alternative ideas identified by researchers.

Children's Ideas about the Earth

Children hold a wide array of ideas about the Earth and Earth-related phenomena, and many of these ideas persist into adulthood (DeLaughter et al., 1998; Libarkin et al., 2005; Libarkin and Anderson, in press). Although popular wisdom held for many years that children outgrow alternative conceptions as they mature, emerging studies indicate that ideas are often persistent and difficult to change (Schoon, 1989; Wandersee et al., 1994; DeLaughter et al., 1998; Libarkin et al., 2005; Libarkin and Anderson, in press). This is reinforced by recent research which suggests that elementary-aged children tend to believe the material contained

within trade books, whether or not the book is story or fact-oriented. Rice and others (2001) found that children changed their ideas based upon book content, regardless of the scientific validity of those ideas. For example, children came away from reading a book about whales believing that whales can count.

An analysis of illustrations contained within the Magic School Bus Earth's Interior trade book highlights the potential impact of trade book illustrations on student ideas. An illustration of the Earth's interior contains a common definitional misconception and may reinforce a widely held alternative conception about the source of volcanic material (Fig. 1). Mixing of the two models of the Earth's interior, one based on chemical composition (crust-mantle-core), and the other based on physical state (lithosphere, asthenosphere, mesosphere, outer core, inner core), is common in K-12 texts, curricula, and even research literature (e.g., Muthukrishna, 1993). The Magic School Bus illustration similarly mixes these two models. The path of the Magic School Bus through the Earth is illustrated with a dotted line that seemingly connects the Earth's center with a magma chamber under a volcano. Due to scale issues, the drawing of the volcano is enlarged relative to the rest of the Earth, with the result that the Earth's interior seems to be providing magma directly to the volcano. This idea is documented in the Essential Science Series (Annenberg/CPB, 2004) and is widely observed in college students enrolled in entry-level geology courses (Fig. 1b).

The degree to which young children relate to trade books may impact both their ability to retain the science behind the book as well as their willingness to modify their alternative conceptions. Whether or not children identify with a trade book may depend on several factors such as representation of gender and race/ethnicity. For example, if girls only see or read about boys in science trade books, they might not identify with the characters and by extension, the subject matter. The prevalence of alternative conceptions in trade books is outside the scope of the current study, but is an important area of focus for future trade book analysis,

Methods

This project involved a detailed content analysis of children's earth science trade books. First, a list of all available books was compiled; the title, author, publication year, and date of the books, as well as the age group in which they were categorized were all recorded. Of the ~400 books available, thirty books (Table 1) that met the following criteria were randomly selected:

- 1) Cost less than \$40.00
- 2) Fell within the 4 to 8 year old age group
- 3) Told a story, rather than listing activities
- 4) Was about earth science in general, rather than a specific topic, such as fossils, volcanoes, or earthquakes, etc...
- 5) Is currently in print

Following book collection, we conducted a content analysis of the books, focusing on technical language and demographics. First, all earth science terms in each book were documented, including how many times the term appeared, whether it was defined, scientifically accurate, illustrated, and whether the illustration was accurate. We also recorded the percentage of each page that was illustrated and how much text was presented. Demographic information which was recorded included the gender and race/ethnicity of the characters.

Data

Between 1979 and 2003, there has been a dramatic increase in the how often technical language used within a trade book is actually defined. This increase is even more prevalent after publication of the NSES (Fig. 2). We counted the incidence of over 200 different earth science terms and recorded the words most often used as well as how many times they were used. For example, the word “rock” was used 731 times within the 30 books. Other words used repeatedly in the 30 books include: Earth (509 times), Mountain (232), Soil (184), Heat/Hot (166), Layer (156), River (150), Volcano/ic (130), Crust (125) and Sand (114).

The demographics of characters in depicted in each book and the gender of the books' authors were also considered in the project. We were able to distinguish between six different racial/ethnic groups (White, Black, Asian, Hispanic, Middle Eastern, and Native American) based on the following trend: ethnicity was represented in illustrations with stereotypical physical characteristics and/or traditional cultural dress. For example, Asian characters were often illustrated with yellow colored skin, small eyes, and dark straight hair, and Middle Eastern characters were distinguished by turbans. Gender was distinguished on the basis of clothing type and length of hair. If the gender or race/ethnicity of the character illustrated was not easily discernable, we did not include that character in the data set. We deduced the gender of the author based on their first names and/or published biographies. Within the time interval studied, no significant change in the representation of sex or race/ethnicity was observed (Figs. 3 & 4). An interesting skewing in gender representation was observed when the gender of the authors was taken into account. Single author books written by both men and women tended to be >60% male in their character representations. Books coauthored by a male and a female demonstrate a sex representation which is similar to the sex representation of the human population (i.e., slightly more females than males). Ethnic representation was not affected by author gender, although most books were heavily weighted towards white character representation.

Results

Through the interpretation of the quantitative data collected in this study, it appears that the quality of children's trade books with earth science content has generally increased through time. This seems to suggest that more recent books may transmit more information. Out of the thirty books included in this project, *The Magic School Bus: Inside the Earth* stands out as the highest quality book, with its rank in the following four categories: (1) the number of different terms appearing in the book, (2) the overall number of terms used, (3) the percent of those terms which were defined and (4) the percent of those terms which were illustrated. In fact, *The Magic School Bus* is the only book which appears within the top 50% (15 of 30 books) of all four categories. This suggests that *The Magic School Bus* educates children using illustrations and definitions (rather than one or the other) and incorporates a large number of earth science terms. Other books which rank in the top 15 in three of the four categories include: *Exploring the Earth with John Wesley Powell*, *Are Mountains Growing Taller?*, *Eye Wonder: Earth, Our World*, *The Pebble in my Pocket*, *Our World: Rocks and Soil*, *Earthsteps: A Rock's Journey Through Time*, *Let's Go Rock Collecting*, *How Mountains are Made*, *What's Inside Earth*, and *The Earth* (by Royston). In total, 12 books appear in the top 15 of each category at least 3 times. These 12 books were then ranked as a whole (Table 1) based on their placement within each category. We are currently ranking books in terms of the demographics.

Conclusions

The implications of this study are potentially far-reaching for those interested in gender and racial equity in science and engineering. Exposing children to the Earth Sciences early on can foster interest in exploring the natural world, and this interest could eventually lead to careers in the natural sciences, engineering, or other scientific fields. Unless children are able to relate to materials used to convey scientific ideas, such as the trade books discussed here, science will remain a field generally unpopulated by minorities. The issue of content and diversity in trade books used in elementary instruction should be revisited, with particular attention to the relationship between early exposure to trade books, the gender and diversity of trade books, and the career paths considered by children. Parents, teachers and school boards can use the data and analyses presented in this study as they choose earth science trade books for use with elementary-aged children. Education researchers can view this report as the start of a much larger study into the quality and utility of children's science books. Most importantly, the content analysis presented in this study raises important questions about the ability of children with diverse backgrounds to relate to these books. In this vein, we are particularly interested in exploring the impact of these books on learning in subsequent studies.

References

- Butzow, C., and Butzow, J., 1988, Facts from fiction: Science and Children, v. 25, p. 27-29.
- Carnine, D., Grossen, B., Miller, S., 1993, Children's alternative frameworks: Should they be directly addressed in science instruction?: Journal of Research in Science Teaching, v. 30, p. 233-248.
- Chapman, V.G., and Sopko, D., 2003, Developing strategic use of combined-text trade books: The Reading Teacher, v. 57, p. 236-239.
- Donovan, C.A., and Smolkin, L.B., 2001, Genre and other factors influencing teachers' book selections for science instruction: Reading Research Quarterly, v. 36, p. 412-440.
- DeLaughter, J.E., Stein, S., and Stein, C.A., 1998, Preconceptions abound among students in an Introductory Earth Science Course: EOS, v. 79, p. 429-432.
- Essential Science for Teachers: Earth and Space Science. Produced by Harvard-Smithsonian Center for Astrophysics. Annenberg/CPB. 2004.
- Libarkin, J.C., Anderson, S., Dahl, J., Beilfuss, M., Boone, W., and Kurdziel, J., College students' ideas about geologic time, Earth's interior, and Earth's crust: Journal of Geoscience Education, in press
- Libarkin, J.C., and Anderson, S.W., Assessment of Learning in Entry-Level Geoscience Courses: Results from the Geoscience Concept Inventory, Journal of Geoscience Education, in press.
- Matthews, M., Gee, D., and Bell, E., 1995, Science learning with a multicultural emphasis: Science and Children, v.5, p. 20-54.
- Mayer, D., 1995, How can we best use literature in teaching?: Science and Children, v.32, p.16-19.
- Muthukrishna, N., Carnine, D., Grossen, B., Miller, S., 1993, Children's alternative frameworks: Should they be directly addressed in science instruction?: Journal of Research in Science Teaching, v. 30, p. 233-248.
- Owens, C.V., 2003, Nonsense, sense and science: Misconceptions and illustrated trade books: Journal of Children's Literature, v. 29, p. 55-62.
- Rice, D.C., Dudley, A.P., and Williams, C.S., 2001, How do you choose science trade books?: Science and Children, v.5, p. 18-22.
- Rogers, A., 2004, Ranking of Earth Science Storybooks, Bryn Mawr College Senior Thesis, 43p.

- Schoon, K.J., 1992, Students' alternative conceptions of Earth and space: Journal of Geological Education, v. 40, p. 209-214
- Taylor, F., 2003, Content analysis and gender stereotypes in children's books: Teaching Sociology, v. 31, p. 300-311.
- Tolman, M.N., Hardy, G.R., and Sudweeks, R.R., 1998, Current science textbook use in the United States: Science and Children, v. 35, p. 22-25.
- Wenze, G.T., 2003, Teaching through trade books: Science and Children, v. 15, p. 14-16.

Contact Information

Aviva Sussman, spring@lanl.gov
 Amanda Rogers, arogers@perkiomen.org
 Julie Libarkin, libarkin@ohio.edu

Figures and Tables

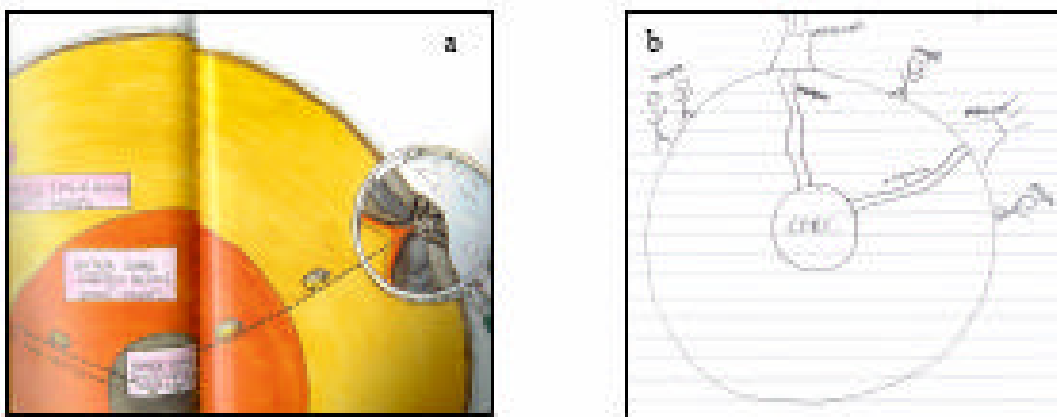


Figure 1: a) Magic School Bus Earth's Interior figure. Dotted line from center of Earth to volcano depicts path of bus. b) College student drawing of Earth's interior. 75% of introductory geology students (N=105) indicated that the source of volcanic material is the Earth's center (Libarkin, unpublished).

Author (year)	Title	Rank
Asch (1994)	The Earth and I	
Berger (2002)	Are Mountains Growing Taller?	3
Charman (1994)	Earth	
Cole (1997)	The Magic School Bus: Inside the Earth	1
Gans (1997)	Let's Go Rock Collecting	9
Gil (1991)	Prof. Curious and the Mystery of the Hiking Dinosaurs	
Goldstein (2003)	Earth	
Grimshaw (1997)	Our World	5
Hatch (2003)	Professor Rock	

Higginson (1994)	Scientists who Study the Earth	
Hooper & Coady (1996)	The Pebble in my Pocket	6
Hurst (2001)	Rocks in his Head	
Kosek (1999)	What's Inside Earth?	11
Kurjian (1993)	In my Own Backyard	
Maddern (1998)	Earth Story	
Manning & Granstrom (1997)	What's Under the Bed?	
Marzollo (2001)	I am Planet Earth	
McNulty (1979)	How to Dig a Hole to the Other Side of the World	
Miller (1998)	If the Earth were a Few Feet in Diameter	
Morris (2002)	Our World: Rocks and Soil	7
Petty & Wood (1993)	Maps and Journeys	
Pluckrose (2001)	Let's Explore Earth	
Ross (2001)	Earth Cycles	
Ross (2000)	Exploring the Earth with John Wesley Powell	2
Royston (1998)	The Earth	12
Spickert (2000)	Earthsteps: A Rock's Journey Through Time	8
Westberg-Peters (1988)	Earthshake: Poems from the Ground Up	
Westberg-Peters (2003)	The Sun, the Wind, & the Rain	
York (2002)	Eye Wonder: Earth	4
Zoehfeld (1995)	How Mountains are Made	10

Table 1: List of books used in this investigation. The books were ranked from 1-12.

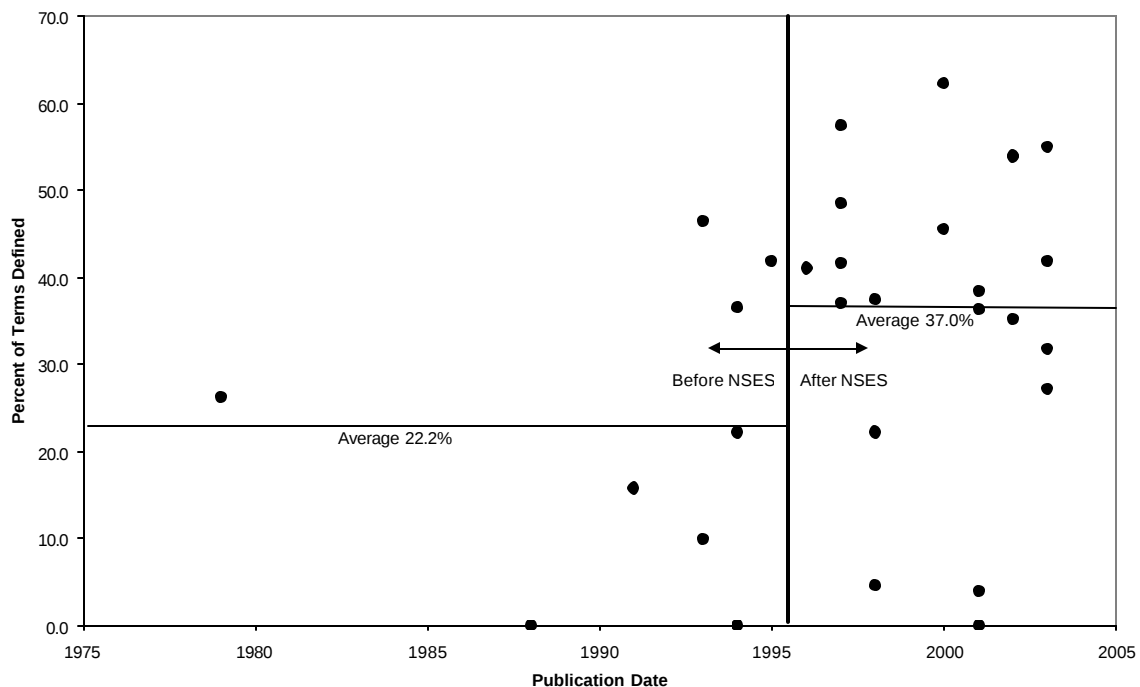


Figure 2: Chart showing a temporal increase in the percent of scientific terms defined, especially following publication of the NSES.

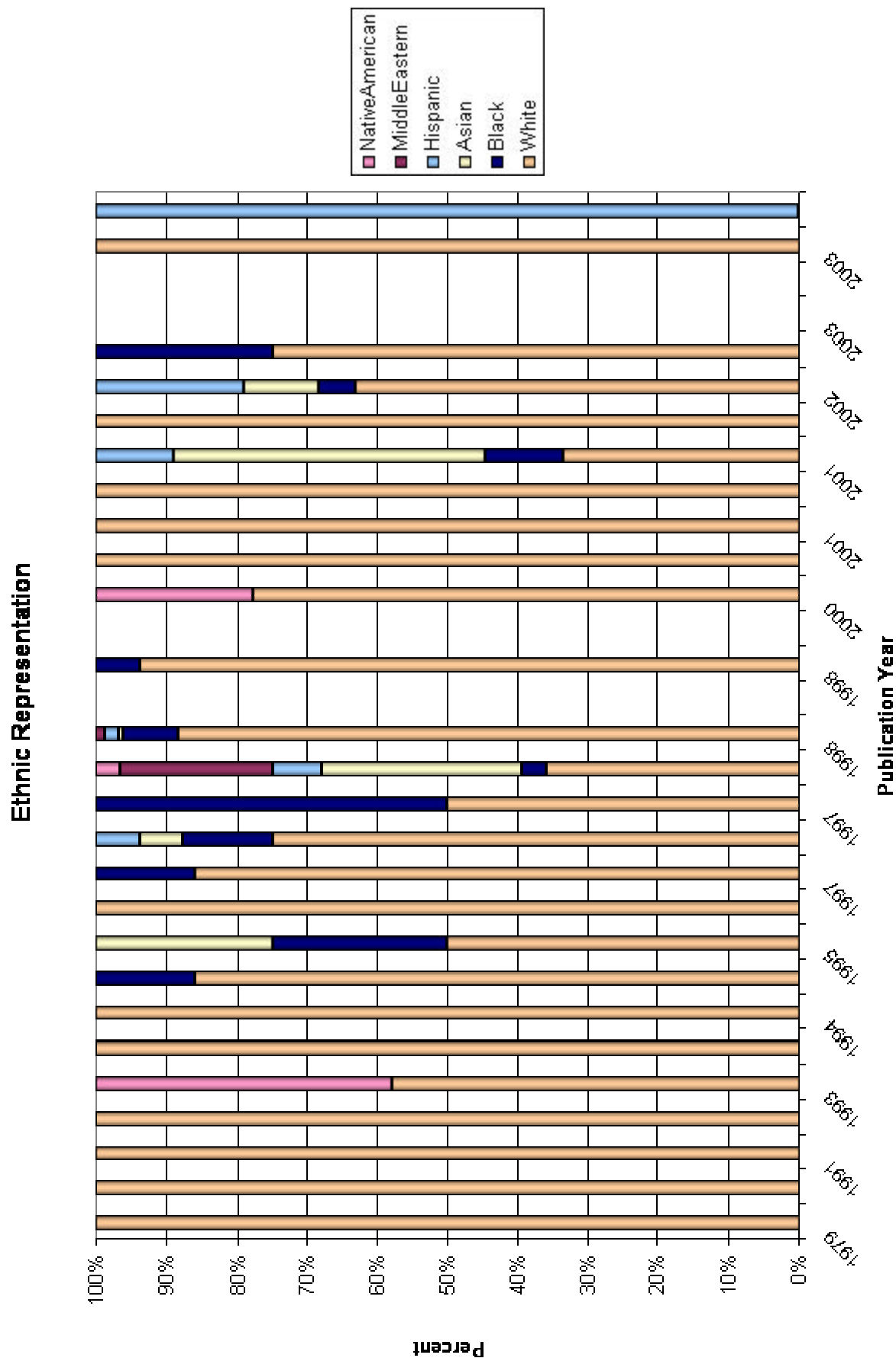


Figure 3: Chart showing the percent distribution of different ethnicities of characters in the analyzed earth science trade books. Note that there is not a significant change in ethnic representation between 1979 and 2003.